(NASA-CR-165077) SPECTROSCOPIC OBSERVATIONS OF COMETS Final Report (Arizona Univ., Tucson.) 9 p HC A02/MF A01 CSCL 03B
N82-16029
Unclas G3/91 07465

Arizona Univ., Tucson

FINAL REPORT NAG 5-86

Spectrocopic Observations of Comets

This is the final report of work performed under a series of grants and work agreements to develop an efficient spectrograph using a micro-channel plate intensifier for the study of faint comets. During the early phases, the design goal was to be able to take useful spectra of comets as faint as $M_2 = 12$. The high sensitivity of the intensifier and improved optical configurations and guiding techniques have resulted in a system capable of obtaining useful spectra of objects 250 times fainter ($M_2 = 18$). The spectrograph is now the key element of a regular program of cometary spectroscopy that benefits a number of other programs as well.

Technical progress over the past year (1980) includes optical coupling of the ISIT vidicon of the 154 cm telescope so that continuous guiding of the object off of the slit is possible. This insures that the spatial profile along the slit is not degraded by trailing. The increased guiding efficiency has resulted in a better signal to noise ratio.

One unique feature of the spectrograph has been the ability to take a direct image of the comet after the spectrum. This aids in the interpretation of the spatial profile of the emissions and helps to characterize the comet morphology. A minor optical reconfiguration now permits shifting between the two modes without refocussing the telescope, and therefore reduce the possibility of operator error. Modifications to the electronics that control the film advance sequencing were made to filter line voltage spikes that caused premature advancing during exposure.

The spectrograph, with features labelled is shown in fig 1, and figs 2 and 3 show sample observations. The observational results are summarized in table 1. Many of the spectra have been made available to other groups, such as the IUE comet investigators, to supplement their data, but digitization and full reduction of the data was outside the scope of this grant. Continuation of the observations and reduction of all of the data is now being carried out on another grant.

The noteworthy results of this grant include the discovery of CO^+ emissions in Comet Schwassmann-Wachmann 1 during quiescent state at 6.3 AU (Larson, 1980). Subsequent observations have shown that the CO^+ emissons are usually present, but are often masked during outbursts when the continuum brightens by six magnitudes. Continued observation during various stages of outburst are being conducted in an attempt to understand the outburst mechanism.

Our spectra of Comets Bradfield (1979ℓ), Encke, Tuttle and Stephan-Oterma have aided the analysis of the IUE spectra. The spectrograph was used on the KPNO 16" to simultaneously identify emissions in Comet Bradfield occurring within filter bandpasses used for wide field imaging by T. Gull and C. Harvel. Near simultaneous spectra of comets Schwassmann-Wachmann 1 and Bowell with wide band filter photometry by Tholen and Tedesco helped to demonstrate the difficulties in comparing comet continuum and asteroid spectrophotometry (Tholen, Tedesco and Larson, 1981). Results have been presented at the Goddard workshop on cometary observing techniques (Larson and Donn, 1981) and IAU Colloquium 61 on comets.

The spectrograph has proven to be a powerful instrument which will

continue to be used on a monthly basis on comets as well as for laboratory comparison experiments conducted in parallel with longer wavelength spectra obtained with a CCD spectrograph. A synthesis of IUE, microchannel plate and CCD spectra of Comet Tuttle will result in the first near-simultaneous spectrum of a comet from .12 to 1μm.

The broadening data base of cometary spectral characteristics obtained with this instrument will aid in placing comets observed from space in the context of a larger comet population and will undoubtedly be applied to Comet Halley as soon as it is observable.

References

Larson, S.M. (1980), CO^+ in Comet Schwassmann Wachmann-1 near minimum brightness. Ap. J. 238 L47-48.

Larson, S.M. and Donn, B. (1981), A systematic program of cometary spectroscopy. Modern Observational Techniques for comets, Brandt, J.C., Donn, B., Greenberg, J.M. and Rahe, J. eds. JPL publication 81-68.

Tholen, D.J., Tedesco, E. and Larson, S.M. 1981. Braodband spectrophotometry of Cometary Coma. BAAS 13, 707. and in prep. for Icarus.

Figure Captions

Figure 1. Two views of the microchannel plate spectrograph/camera. Left interior view shows the light path (solid line) and alternate paths to field viewing eyepiece and sensitometer (dashed lines). Conversion to the direct imaging mode is accomplished by removing the slit and replacing the grating with a plane mirror. The sensitometer projects either a density wedge, a uniform field, or a resolution chart with either a tungsten lamp or standard spectral emission lamps. The right hand view shows the power supply and film advance controls. The eyepiece are for viewing the field directly or off of the slit. The tube above the mounting flange holdsthe transfer optics for the slit viewing ISIT camera.

Figure 2. Sample observation of P/Encke showing the fan-shaped coma in the direct image, the spectrum, and density traces through the nucleus and 12,000 km away.

Figure 3. Sample series of observations of P/Stephan-Oterma (1980g) showing spectral changes with heliocentric distance.

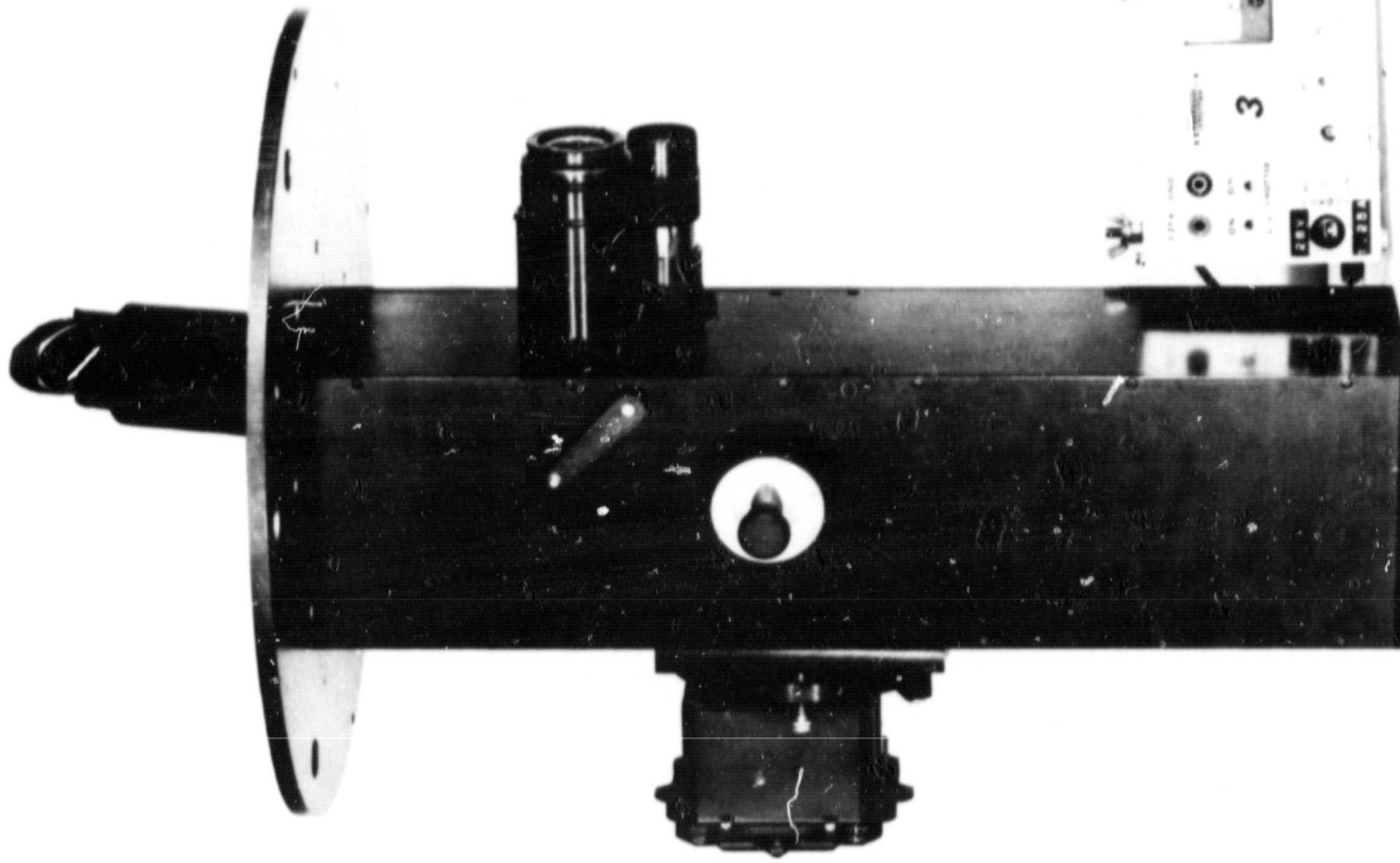
LPL/GSFC COMET SPECTRA AS OF 820101

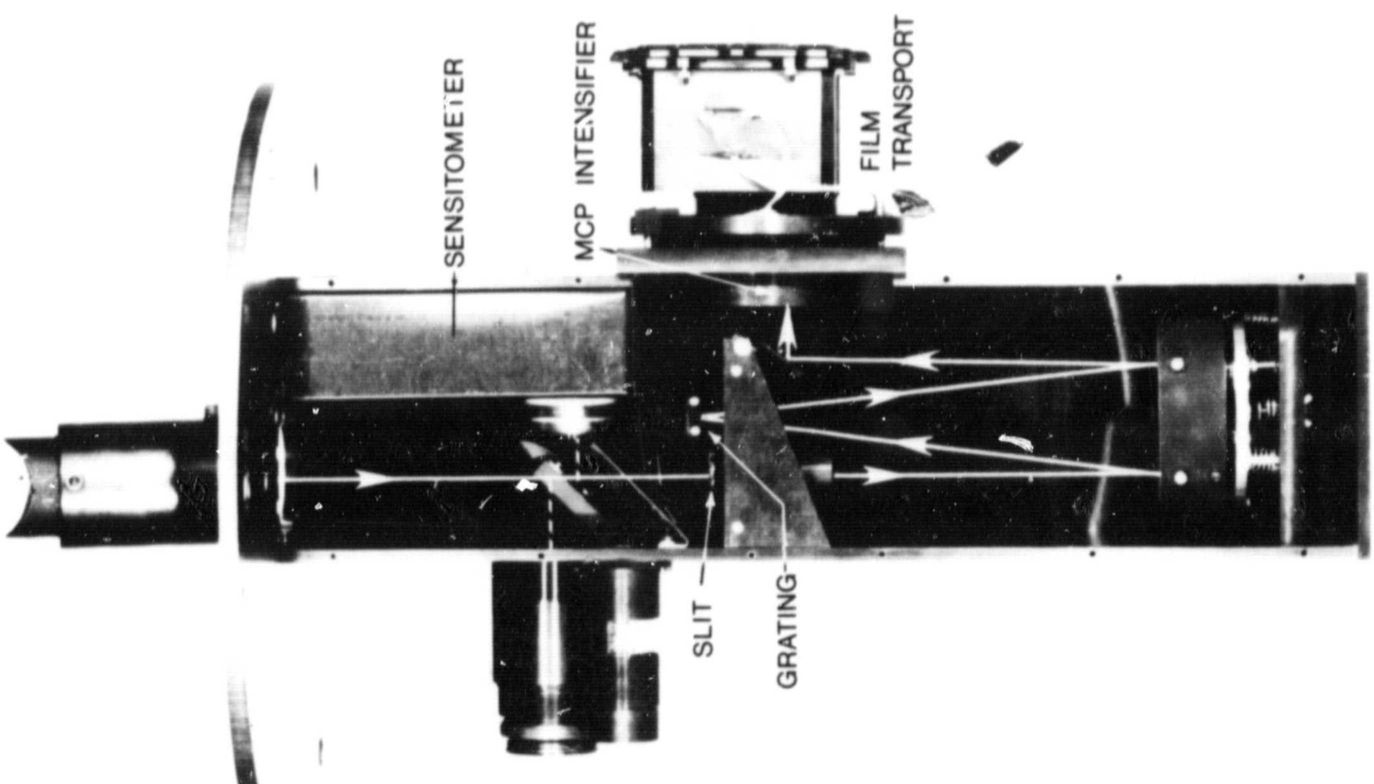
NAME / DATE	R	D	A	M2	E	W	T	S
P/ASHBROOK-JACKSON [1977G]								
780903.241	2.28	2.42	000	11.8	30	.35-.59	H	
780903.271	2.28	2.42	000	11.8	30	.35-.59	H	
781006.227	2.31	1.32	000	11.6	20	.35-.59	H	
P/BORRELLY [198]								
810330.127	1.38	1.76	000	10	30	.30-.56	M	OH NH CN C3 C2
BOWELL [1980B]								
800410.250	7.21	6.50	000	16.5	60	.30-.56	H	
800507.192	6.90	6.50	000	16.0	55	.30-.56	H	
801215.527	5.36	5.49	000	14	58	.35-.58	H	
801216.517	5.36	5.49	000	14	60	.35-.58	H	
810330.332	4.68	3.69	000		60	.35-.58	H	
810602.247	6.70	6.78	000	13	60	.30-.56	H	
BRADFIELD [1979L]								
800204.104	1.09	0.41	000	6.2	10	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.115	1.09	0.41	000	6.2	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.136	1.09	0.41	000	6.2	19	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.146	1.09	0.41	000	6.2	7	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.158	1.09	0.41	000	6.2	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.116	1.11	0.44	000	6.9	40	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.140	1.11	0.44	000	6.9	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.155	1.11	0.44	000	6.9	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.171	1.11	0.44	000	6.9	20	.30[.56	L	OH NH CN C3 CH C2 CO2+
800318.159	1.75	0.84	000	14	30	.30-.56	H	
P/ENCKE								
801009.507	1.27	0.49	000	9.4	27	.30-.56	L	OH CN C3 C2
801104.498	0.83	0.31	000	6.8	51	.30-.51	L	OH NH CN C3 CH C2
P/GICLAS								
781008.261	1.78	0.83	000	15.6	20	.35-.59	H	
HOWELL [1981K]								
811031.260	2.28	1.45	000	16	60	.30-.56	M	CN
811101.186	2.28	1.45	000	16	60	.30-.59	M	CN
P/KEARNS KWEE [198]								
811031.447	2.24	1.60	000	16	60	.30-.56	M	CN
811101.444	2.24	1.60	000	16	60	.30-.56	M	CN
811102.427	2.23	1.59	000	16	60	.30-.59	M	CN
KOHLER [1977M]								
771019.097	1.06	1.10	000	7.4	20	.35-.59	L	NH CN C3 CH C2 NH2
771019.108	1.06	1.10	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.066	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.076	1.06	1.03	000	7.4	20	.35-.59	L	NH CN C3 CH C2 NH2
771206.090	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.101	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771207.066	1.06	1.03	000	7.6	10	.35-.59	L	NH CN C3 CH C2 NH2
771207.076	1.06	1.03	000	7.6	10	.35[.59	L	NH CN C3 CH C2 NH2
P/MEIER [1978F]								
780517.221	2.77	3.16	000	10	20	.35-.59	M	CN C2
780518.234	2.77	3.16	000		20	.35-.59	M	CN C2
780607.204	2.60	3.15	000	8.6	20	.35-.59	M	CN C3 C2
780607.216	2.60	3.15	000	8.6	10	.35-.59	M	CN C3 C2
780608.160	2.60	3.15	000		20	.35-.59	M	CN C3 C2
780608.174	2.60	3.15	000		10	.35-.59	M	CN C3 C2
P/MEIER [1980Q]								
810127.490	1.67	2.00	000	9	30	.30-.56	H	CN C3 C2
PANTHER [1980U]								
810127.530	1.64	1.64	000	8	30	.30-.56	H	OH NH CN C3 CH C2
810602.177	2.35	2.76	000	12	32	.30-.56	M	NH CN C2

ORIGINAL PAGE IS
OF POOR QUALITY

LPL/GSFC COMET SPECTRA AS OF 820101

NAME DATE	R	D	A	M2	E	W	T	S
P/ASHBROOK-JACKSON [1977G]								
780903.241	2.28	2.42	000	11.8	30	.35-.59	H	
780903.271	2.28	2.42	000	11.8	30	.35-.59	H	
781008.227	2.31	1.32	000	11.6	20	.35-.59	H	
P/BORRELLY [198]								
810330.127	1.38	1.76	000	10	30	.30-.56	M	OH NH CN C3 C2
BOWELL [1980B]								
800410.250	7.21	6.50	000	16.5	60	.30-.56	H	
800507.192	6.90	6.50	000	16.0	55	.30-.56	H	
801215.527	5.36	5.49	000	14	58	.35-.58	H	
801216.517	5.36	5.49	000	14	60	.35-.58	H	
810330.332	4.08	3.69	000		60	.35-.58	H	
810602.247	6.70	6.78	000	13	60	.30-.56	H	
BRADFIELD [1979L]								
800204.104	1.09	0.41	000	6.2	10	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.115	1.09	0.41	000	6.2	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.136	1.09	0.41	000	6.2	19	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.146	1.09	0.41	000	6.2	7	.30-.56	L	OH NH CN C3 CH C2 CO2+
800204.158	1.09	0.41	000	6.2	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.116	1.11	0.44	000	6.9	40	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.140	1.11	0.44	000	6.9	20	.30-.55	L	OH NH CN C3 CH C2 CO2+
800205.155	1.11	0.44	000	6.9	20	.30-.56	L	OH NH CN C3 CH C2 CO2+
800205.171	1.11	0.44	000	6.9	20	.30[.56	L	OH NH CN C3 CH C2 CO2+
800316.159	1.75	0.84	000	14	30	.30-.56	H	
P/ENCKE								
801009.507	1.27	0.49	000	9.4	27	.30-.56	L	OH CN C3 C2
801104.498	0.83	0.31	000	6.8	51	.30-.51	L	OH NH CN C3 CH C2
P/GICLAS								
781008.261	1.78	0.83	000	15.6	20	.35-.59	H	
HOWELL [1981K]								
811031.260	2.28	1.45	000	16	60	.30-.56	M	CN
811101.186	2.28	1.45	000	16	60	.30-.59	M	CN
P/KEARNS KWEE [198]								
811031.447	2.24	1.60	000	16	60	.30-.56	M	CN
811101.444	2.24	1.60	000	16	60	.30-.56	M	CN
811102.427	2.23	1.59	000	16	60	.30-.59	M	CN
KOHLER [1977M]								
771019.097	1.06	1.10	000	7.4	20	.35-.59	L	NH CN C3 CH C2 NH2
771019.108	1.06	1.10	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.066	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.076	1.06	1.03	000	7.4	20	.35-.59	L	NH CN C3 CH C2 NH2
771206.090	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771206.101	1.06	1.03	000	7.4	10	.35-.59	L	NH CN C3 CH C2 NH2
771207.066	1.06	1.03	000	7.6	10	.35-.59	L	NH CN C3 CH C2 NH2
771207.076	1.06	1.03	000	7.6	10	.35[.59	L	NH CN C3 CH C2 NH2
P/MEIER [1978F]								
780517.221	2.77	3.16	000	10	20	.35-.59	M	CN C2
780518.234	2.77	3.16	000		20	.35-.59	M	CN C2
780607.204	2.60	3.15	000	8.6	20	.35-.59	M	CN C3 C2
780607.216	2.60	3.15	000	8.6	10	.35-.59	M	CN C3 C2
780608.160	2.60	3.15	000		20	.35-.59	M	CN C3 C2
780608.174	2.60	3.15	000		10	.35-.59	M	CN C3 C2
P/MEIER [1980Q]								
810127.490	1.67	2.00	000	9	30	.30-.56	H	CN C3 C2
PANTHER [1980U]								
810127.530	1.64	1.64	000	8	30	.30-.56	H	OH NH CN C3 CH C2
810602.177	2.35	2.76	000	12	30	.30-.56	M	NH CN C2

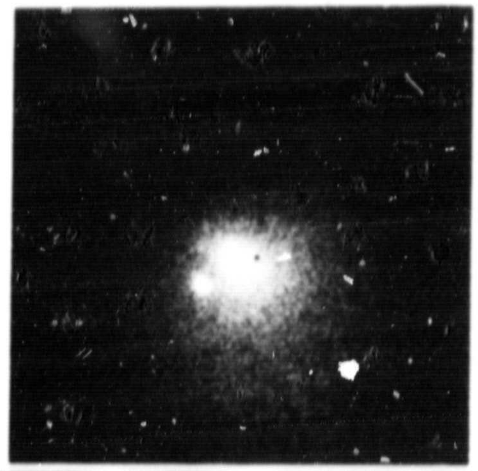


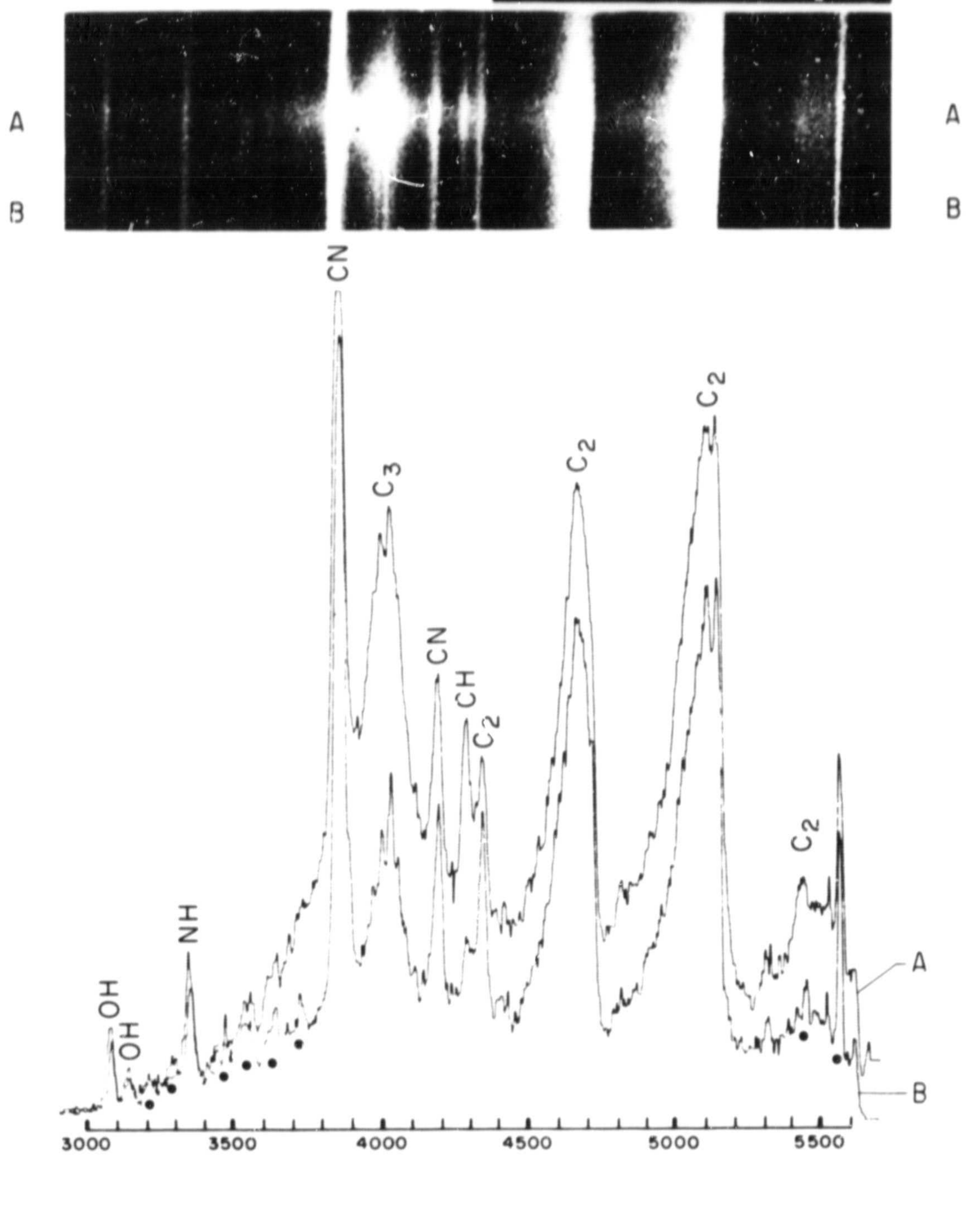

SENSITOMETER
MCP INTENSIFIER
FILM
TRANSPORT
SLIT
GRATING

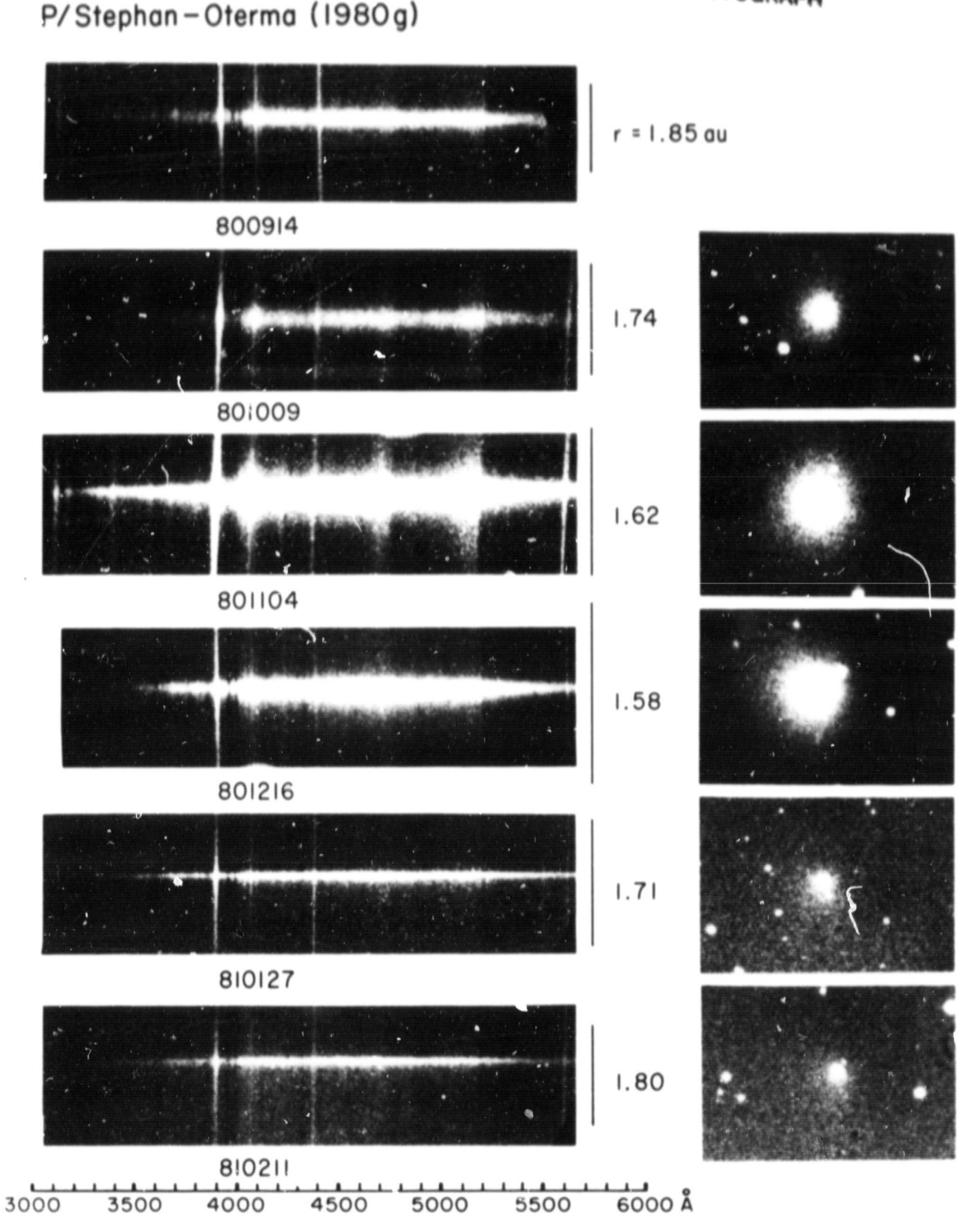
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

P/ENCKE

1980 November 4.5
r = 0.8 AU
A-B = 12,000 km






P/Stephan-Oterma (1980g)
r = 1.85 au
800914
1.74
801009
1.62
801104
1.58
801216
1.71
810127
1.80
810211
3000
3500
4000
4500
5000
5500
6000 Å